



NOV 2023, LINK-SIC WORKSHOP 2023

Life as LINK-SIC PhD student and beyond

Fredrik Ljungberg

—

My work in LINK-SIC

PhD project

Ship modelling for estimation and control

Overall goals

Simplified ship commissioning by:

- Accurate model estimation
- Reduced time for data collection experiments

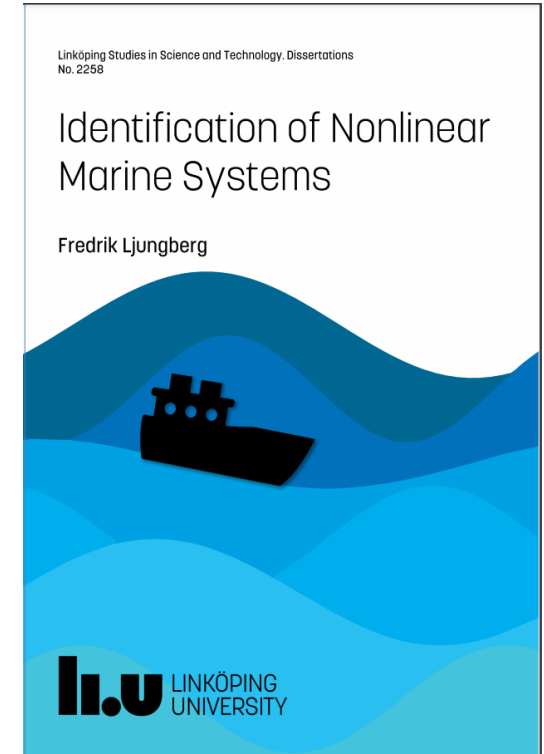


Key concepts

- Physical modelling
 - Second-order modulus models:
 - $f(x) = x|x| \dots$
- System identification
 - Parameter estimation with robustness to environmental disturbances (wind, waves currents)
- Experiment design
 - Informative mix of standard maneuvers (zig-zag, spiral, circle tests etc.)



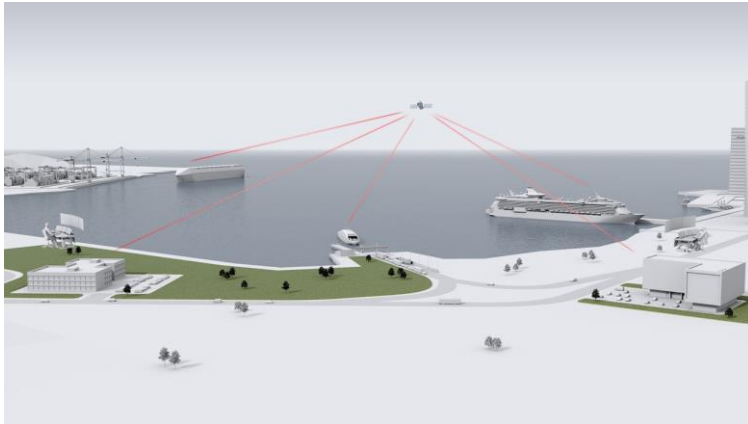
PhD thesis



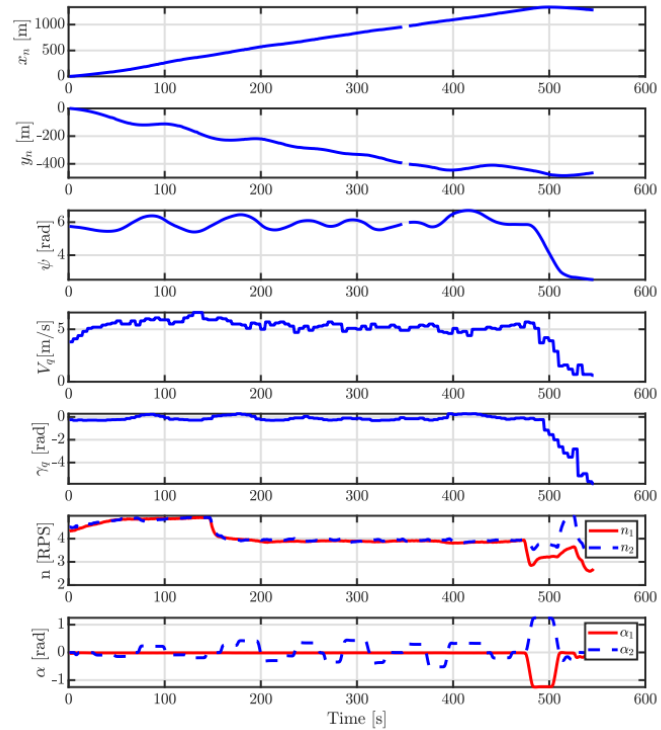
Benefits of being a LINK-SIC PhD student

Industrially relevant research questions

- Fun and challenging problems
- Increased self-motivation
- Easy justification for research in publications
- Different companies bring different aspects



Access to real experimental data



Additional networking opportunities

- Yearly workshops
- Opportunity for feedback on research
- Interesting study visits
- Personal contacts at companies
- Other LINK-SIC PhD students



Other LINK-SIC related collaborations

SAAB WARA-PS

Model estimation for USV “Piraya”

- Collaboration with Saab Kockums AB and WARA-PS through Kristoffer Bergman (industrial PhD student).
- The model is now used in a WASP course.



Model boat

Assembly of model boat for data collection

- Collaboration with Erik Hedberg (PhD student within LINK-SIC) that was followed up by two MSc projects and a CDIO project (in collaboration with ABB).
- The collected data was used both in a journal paper and in the PhD thesis.



Experiment design

Input design for industrial manipulators/ships

- Indirect collaboration with ABB robotics through Stefanie Zimmermann (PhD student within LINK-SIC).
- Clear synergies in development of experiment design for industrial manipulators and ships.



My work now at ABB Corporate Research

Decentralized business model with 20 divisions

BUSINESS AREA

Electrification



Distribution Solutions

Smart Power

Smart Buildings

Installation Products

Power Conversion¹

Service

E-mobility²

Motion



IEC LV Motors

Large Motors & Generators

NEMA Motors

Drive Products

System Drives

Motion Service

Traction

Process Automation



Energy Industries

Process Industries

Marine & Ports

Measurement & Analytics

Robotics & Discrete Automation



Robotics

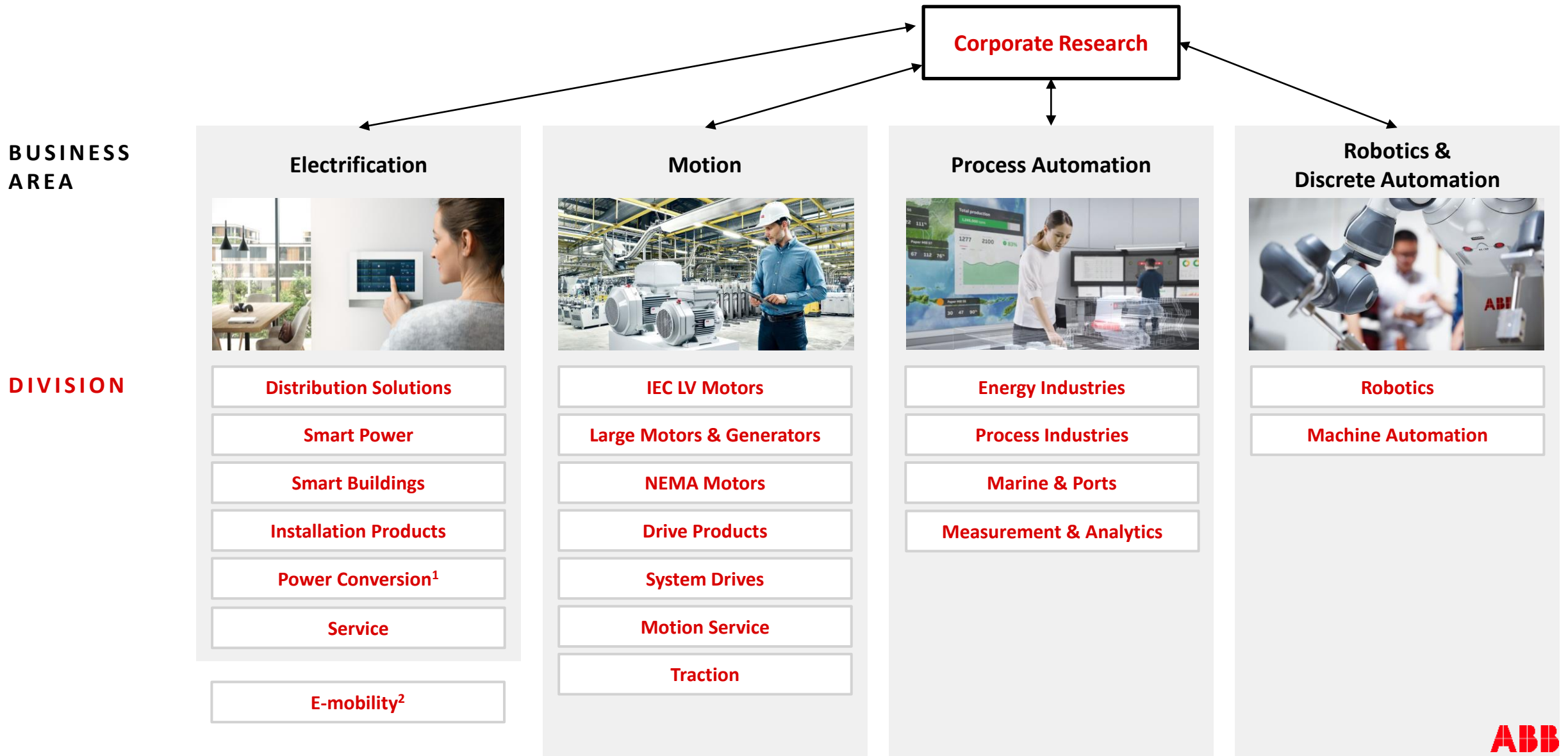
Machine Automation

DIVISION

ABB

1. Divestment announced. Expected to be completed in H2 2023. 2. Reported as part of "Corporate and Other" as of Q1 2023.

Decentralized business model with 20 divisions



1. Divestment announced. Expected to be completed in H2 2023. 2. Reported as part of "Corporate and Other" as of Q1 2023.

ABB Research

Research and technology for the future

ABB Research Sweden

Facts

- Located in Västerås
- Established 1916
- 90 Co-workers (24 nationalities)
- 48% PhD researchers
- 10 Associate professors/affiliated faculty
- Hosting SynerLeap
- University collaborations
 - KTH, Chalmers, LiU, MDU, LTU...
 - Imperial College, Aalto, ETH....





My current work

Example 1: Renewable energy in mining operations

The renewable race is on!

Home > Commodities > Mining industry in South Africa to generate 5.1 GW of electricity

Commodities Latest News News World

Mining industry in South Africa to generate 5.1 GW of electricity

By Anita Anyango - 8th Aug 2022

64 0

Facebook Twitter WhatsApp Telegram



South African mining industry is set to generate 5.1 GW of electricity, a move that is coming at time when the South African government is taking urgent action to reform the power sector and bring new capacity online.

Zenith plans Australia's largest off-grid hybrid power plant for mining op

Liontown Resources is set to install what could be Australia's largest off-grid renewable energy hybrid power station, at its AUD 545 million (\$374.5 million) Kathleen Valley Lithium Project in Western Australia.

SEPTEMBER 13, 2022 DAVID CARROLL

TECHNOLOGY AND R&D UTILITY SCALE PV UTILITY SCALE STORAGE AUSTRALIA



Zenith will supply power to Kathleen Valley on a build-own-operate basis.

Image: Zenith Energy

Share Facebook Twitter LinkedIn WhatsApp Email



From pv magazine Australia

Perth-based Liontown Resources is the latest mining company to back renewables to power its off-grid operations, engaging remote power generation specialist Zenith Energy to build a 95 MW hybrid solar PV, wind and battery energy storage system at its Kathleen Valley Lithium Project in Western Australia.

Australia's huge new nickel mine will host world's biggest renewable micro-grid

Giles Parkinson 24 September 2022

9



115 Shares

Share 115

Tweet

Envelope icon

LinkedIn icon

Reddit icon

Share icon

The massive \$1.7 billion West Musgrave nickel and copper project – given the green light by Australian mining company Oz Minerals late last week – will be a groundbreaking project for the sheer scale and influence of the renewable energy resources it proposes to harness.

Critical raw materials for the transition

Significant increase in needs foreseen

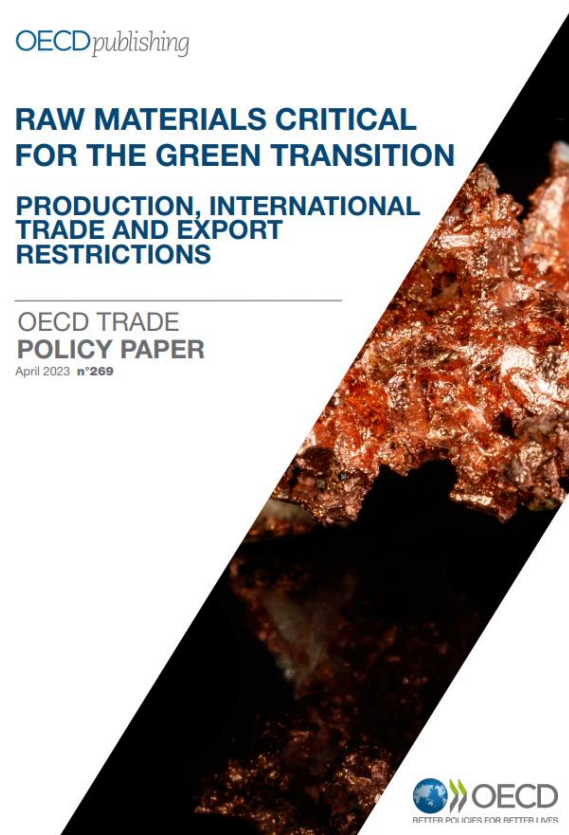
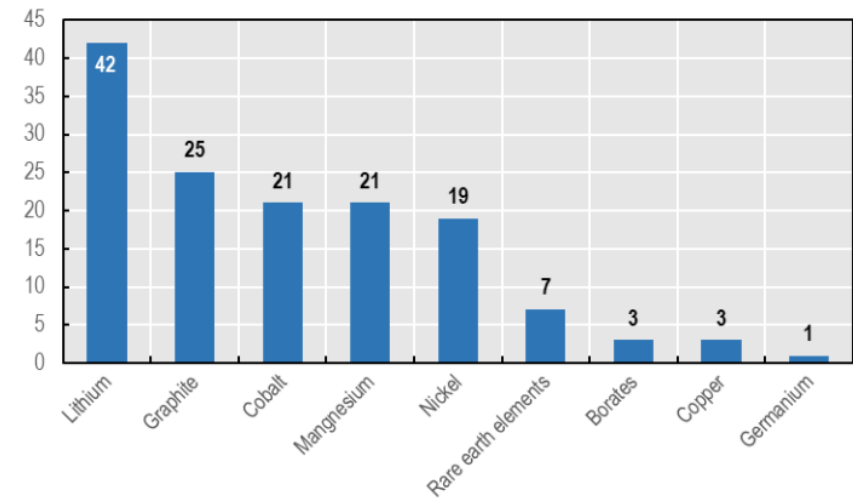


Figure 1.1. Projected global demand growth for certain raw materials by 2040

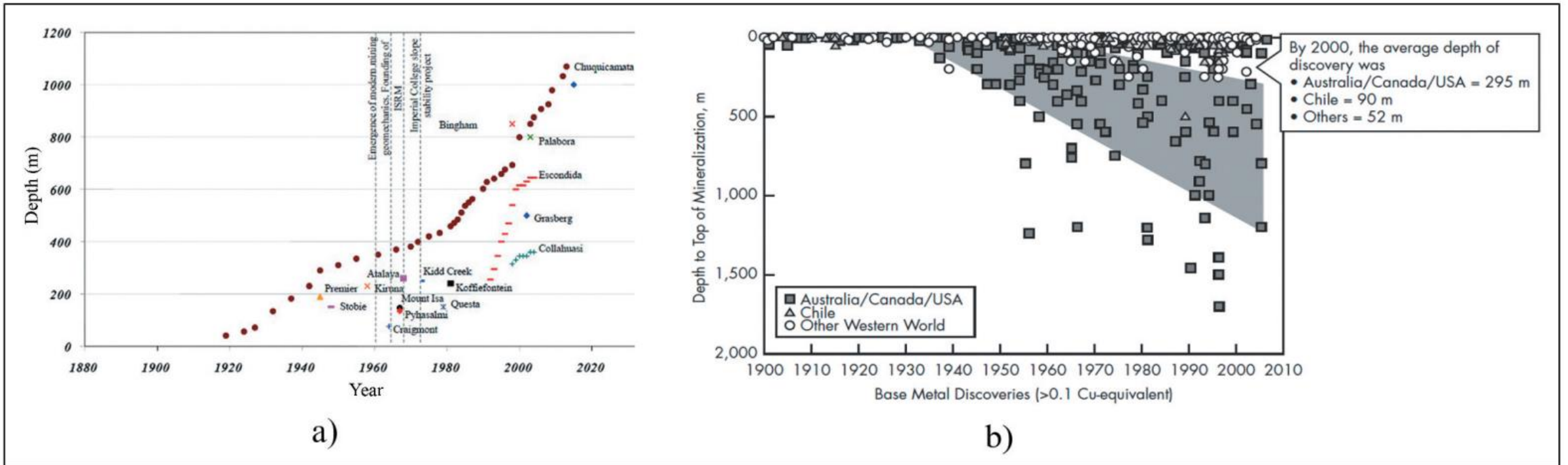
Projected increase factor (1= current demand)



Note: International Energy Agency's Sustainable Development Scenario, which indicates what would be required in a trajectory consistent with meeting the Paris Agreement goals.

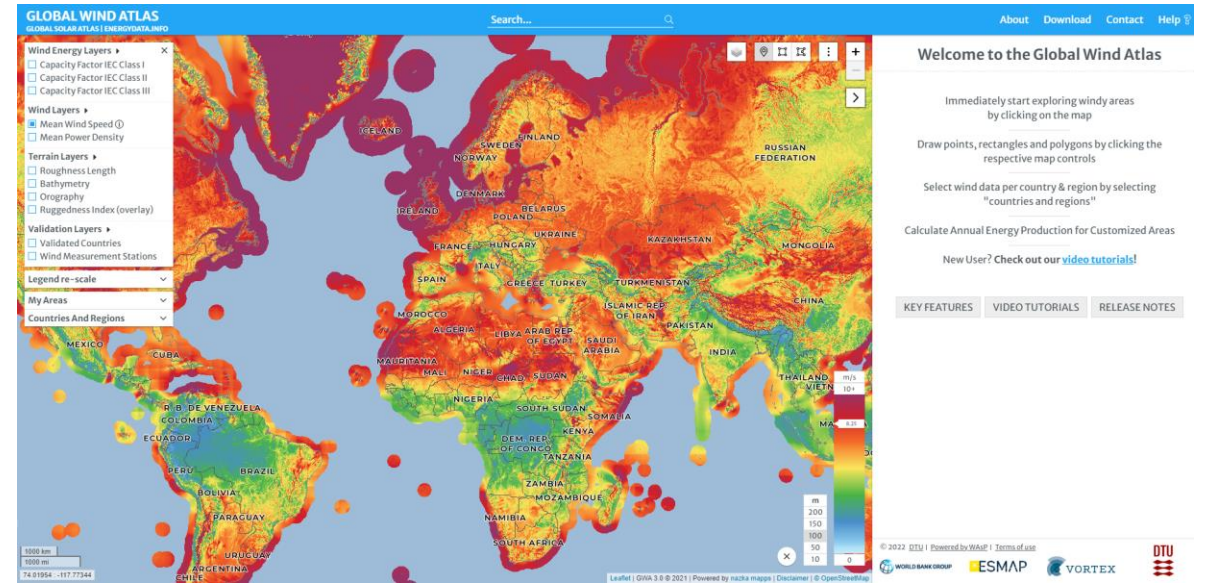
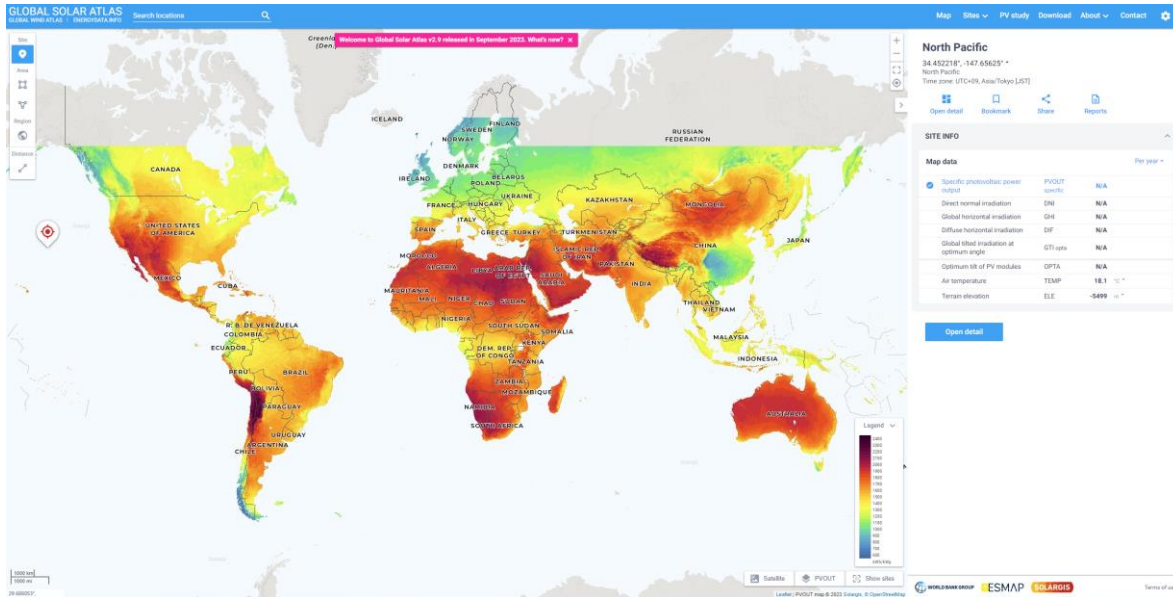
Source: (IEA, 2021[2]).

The depths of open-pit mines have significantly increased over the decades



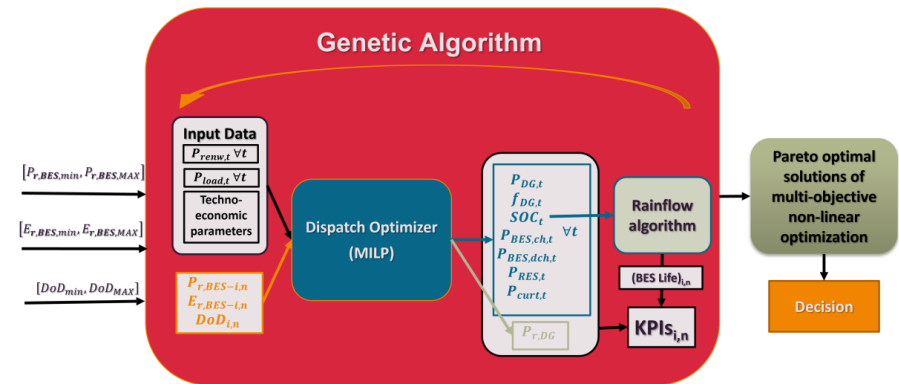
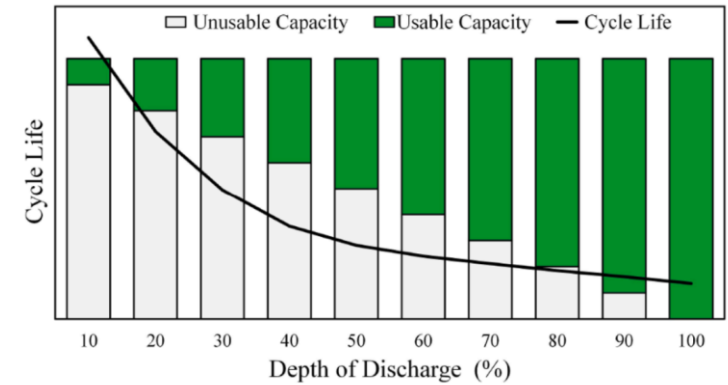
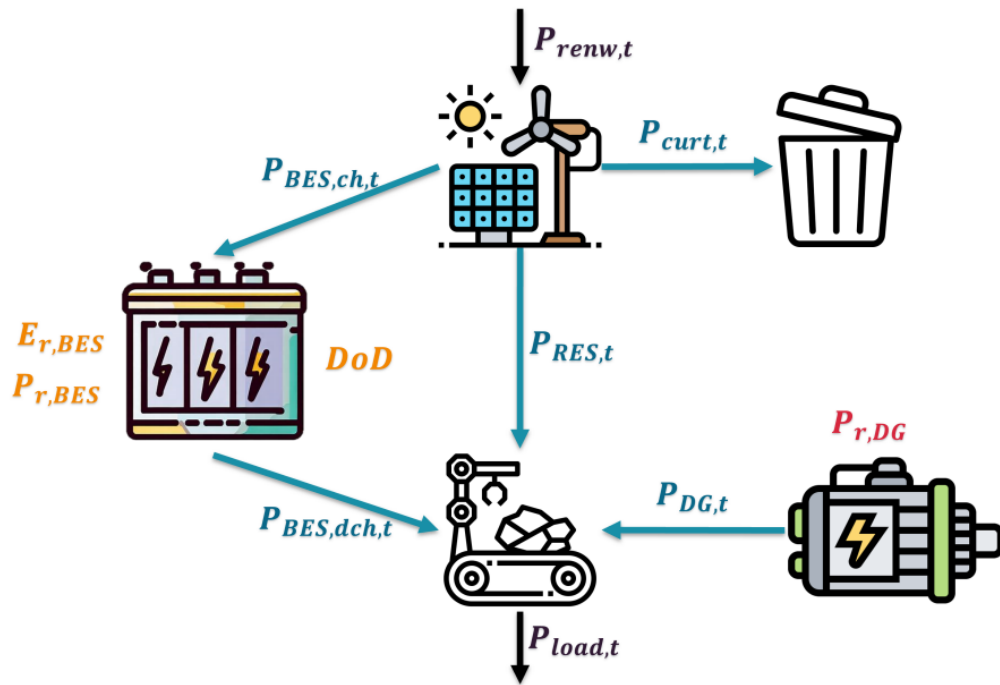
Getting the local resources of solar and wind

All sites are different!



Optimal sizing of battery energy storage in underground mines (I/II)

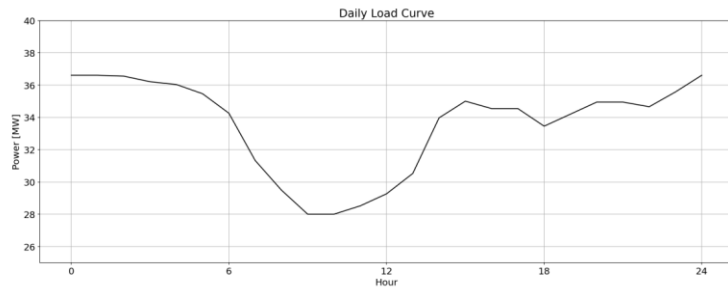
Case study from MSc thesis*



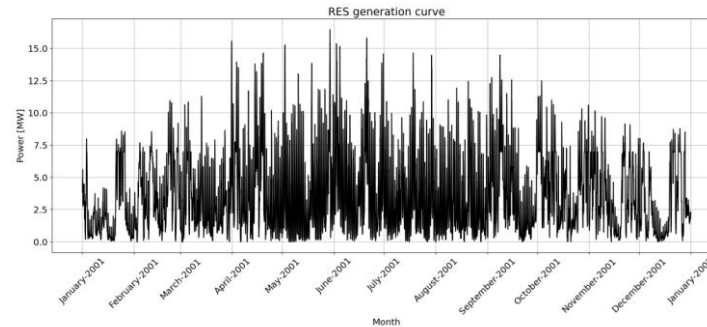
Optimal sizing of battery energy storage in underground mines (II/II)

Case study from MSc thesis*

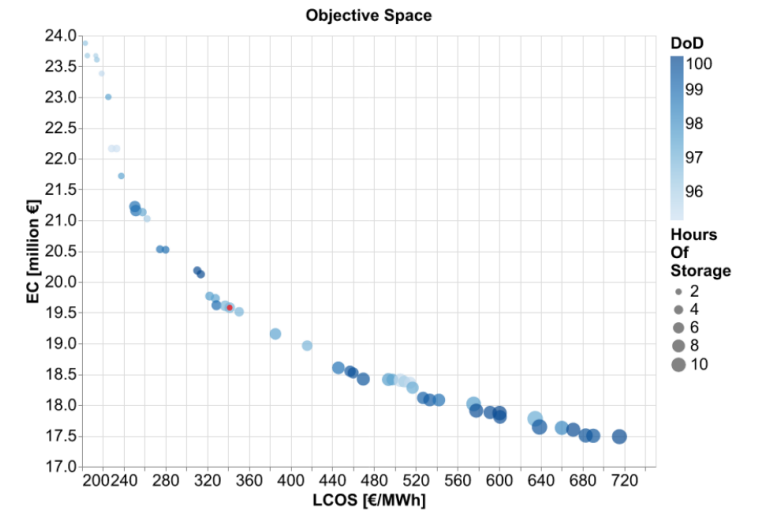
Daily load curve of a mine



Yearly renewable generation of a mine



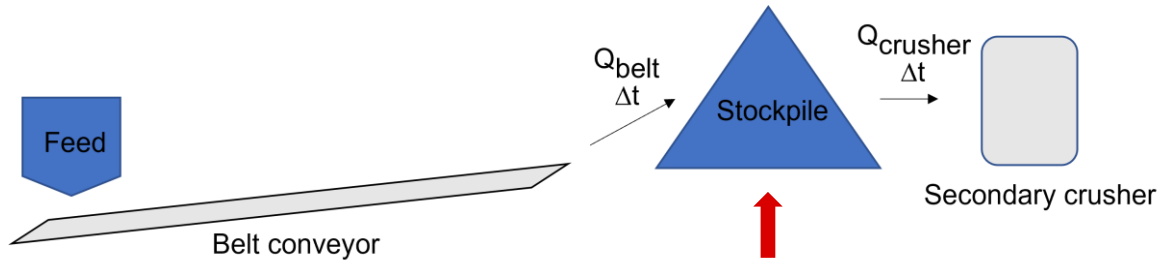
Emission cost vs levelized cost of storage



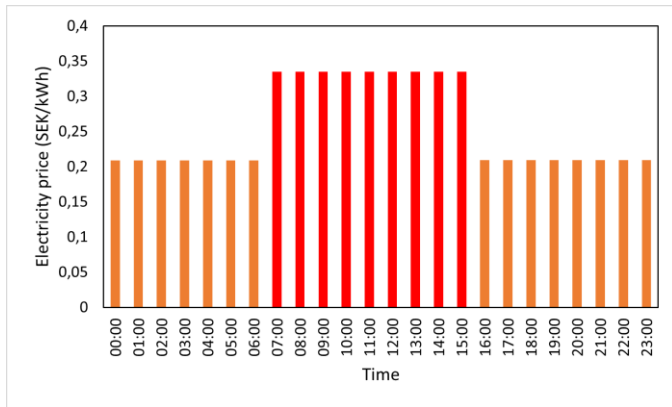
Pareto-optimal solutions based of carbon taxes and cost of batteries

Stockpiling material between conveyor belt and crusher (I/II)

Case study from MSc thesis*



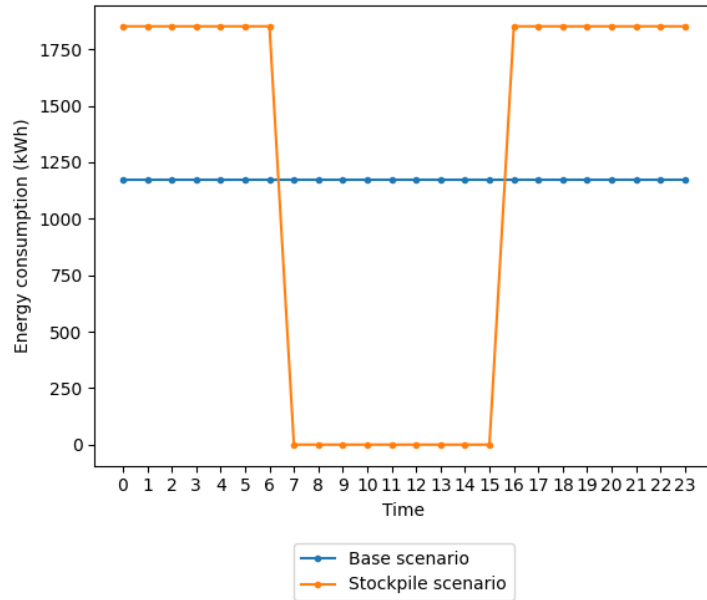
$$S_t = S_{t-1} + Q_{belt}\Delta t - Q_{crusher}\Delta t$$



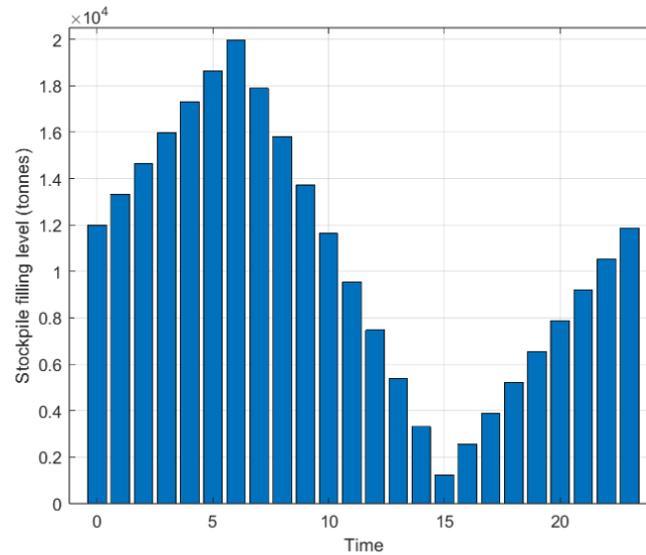
Stockpiling material between conveyor belt and crusher (II/II)

Case study from MSc thesis*

Energy use per hour



Stockpile filling-grade



Cost reduction

	Baseline scenario	Stockpile scenario	Difference
Electricity cost (SEK)	7212	5811	-19.43%

19.43 % savings in electricity cost!



My current work

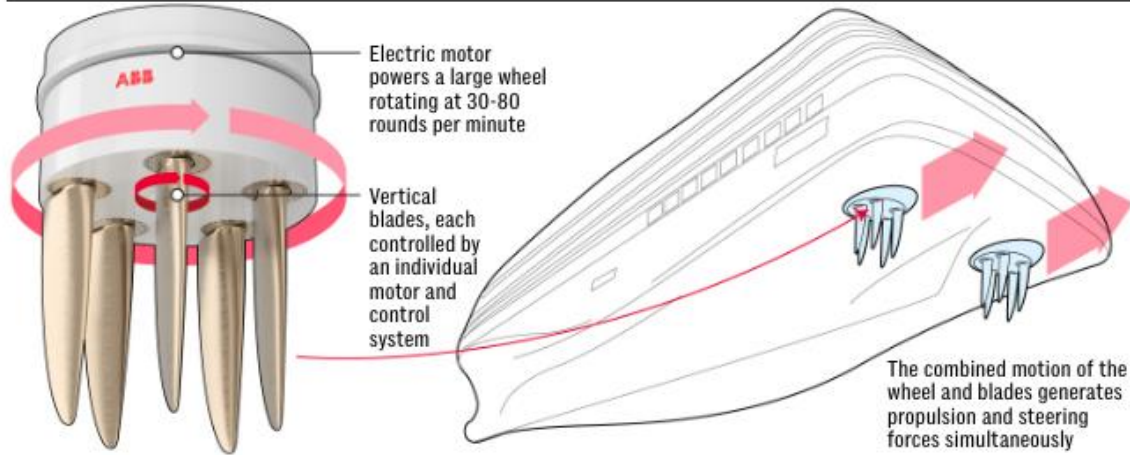
Example 2: Next generation of ship propulsion

Three generations of ship propulsion

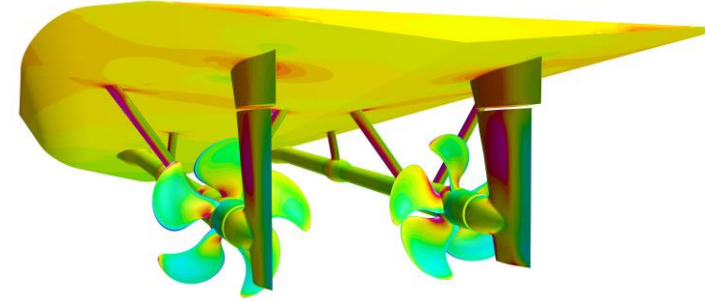
On May 31, ABB launched the latest propulsion innovation “Dynafin”

Dynafin

How the Dynafin works



Propeller/rudder



Azipod



Dynafin propulsion

Advantages

- Improved maneuverability through faster response times
 - Precise dynamic positioning
 - Suited for demanding operations (e.g., severe weather)
- Better propulsion efficiency (~20 %)
- Reduced underwater noise



Control challenges

- Blade pitch can be changed significantly faster than speed and direction
 - Stiff system (highly separated time constants)
- Over actuation (many control signals -> thrust in 2 degrees of freedom)
 - Non-uniqueness of solution
 - Performance/energy balancing required



—

Summary

Summary

LINK-SIC and beyond

- **In PhD studies:**
 - Collaboration with ABB
 - Ship modelling for estimation and control
- **Now:**
 - Working at ABB
 - Various fun research projects

Renewable energy in mining operations



Automated ships



Being a LINK-SIC PhD student turned out well!

ABB